BUF1113 BASIC PHYSICS

PHYSICS AND MEASUREMENT

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CHAPTER DESCRIPTION

- Aims
  - Student should use appropriate prefixes in calculations, manipulate the dimensional analysis and perform unit conversions.
- Expected Outcomes
  - Able to resolve physical quantity and International systems of measurement
  - Able to use appropriate prefixes in calculations
  - Able to determine the S.I unit of physical quantity, homogeneity of an equation and to construct an equation
  - Able to perform the dimensional analysis
  - Able to perform unit conversions
- References
  - Giancoli, D.C. Physics for Scientists and Engineers: with Modern Physics (4th Edition). Pearson Prentice Hall, 2013
  - Paul E. Tippens, Physics 7th Edition. Mc Graw Hill, 2013
  - Physics for scientists and engineers / Raymond A. Serway, John W. Jewett, Australia : Cengage Learning, 2014

CONTENT

1.1 Standard of Length, Mass and Time

1.2 Dimensional Analysis

1.3 Conversion of Unit

1.1 Standard of Length, Mass and Time

- A physical phenomenon such as size, length etc. of an object that can describe quantitatively is called physical quantity.
- The measurement of the physical quantity is up to a particular standard or unit e.g 10 m length or 100 ^{o}C of temperature
- ...and this unit must be write along with the numerical value
  - For e.g. : 3.5 cm is differ from 3.5 inches or 3.5 mm.

1.1 Standard of Length, Mass and Time

- For any unit, we need to define a standard.
- The most common unit used around the world is International System of Units, SI Unit
- Is commonly known as "metric system".
- In 1960, it is known as International System, or SI (in French, *Système International*).
- **7 base** quantities – official base units

Quantity	Unit	Unit Abbreviation
Length	meter	m
Time	second	S
Mass	kilogram	Kg
Electric Current	ampere	A
Temperature	kelvin	K
Amount of Substance	mole	mol
Luminous Intensity	candela	cd

1.1 Standard of Length, Mass and Time

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Length of the path traveled by light in 1/299,792,458 second

Time required for 9,192,631,770 periods of radiation emitted by cesium atoms

Platinum cylinder in International Bureau of Weights and Measures, Paris

- Each of the base unit has a specific measurable definition

1.1 Standard of Length, Mass and Time

- Length – distance between two point along an object

Length	Meters
Atom (diameter)	10^{-10} m
Virus	10^{-7} m
Finger width	10^{-2} m
Earth to Sun	10^{11} m

1.1 Standard of Length, Mass and Time

- Time – duration or continuous measurable quantity between events (past, present and future).

Time Interval	Seconds
One day	10^5 m
Human life span	2 x 10^9 m
Life on earth	10^{17} m
Age of Universe	10^{18} m

1.1 Standard of Length, Mass and Time

- Mass – amount of matter in an object

Object	Kilograms
Electron	10^{-30} kg
Proton, neutron	10^{-27} kg
Mosquito	10^{-5} kg
Human	10^{2} kg
Ship	10^{8} kg
Sun	2×10^{30} kg
Galaxy	10^{41} kg

1.1 Standard of Length, Mass and Time

- Prefixes correspond to powers of 10

We usually express multiples of 10 or 1/10 in index notation:

$$1000 = 10^3 \qquad \frac{1}{1000} = 10^{-3}$$

- Prefix has a *specific name* such nano, pico.
- Prefix has a *specific abbreviation e.g μ, G.*
- Prefixes are multipliers and can be used with any basic units

1.1 Standard of Length, Mass and Time

- List of standard SI prefixes.

Table 5. SI prefixes

Factor	Name	Symbol	Factor	Name	Symbol
10^{24}	yotta	Y	10^{-1}	deci	d
10^{21}	zetta	Z	10^{-2}	centi	c
10^{18}	exa	E	10^{-3}	milli	m
10^{15}	peta	P	10^{-6}	micro	µ
10^{12}	tera	T	10^{-9}	nano	n
10^{9}	giga	G	10^{-12}	pico	p
10^{6}	mega	M	10^{-15}	femto	f
10^{3}	kilo	k	10^{-18}	atto	a
10^{2}	hecto	h	10^{-21}	zepto	z
10^{1}	deka	da	10^{-24}	yocto	y

1.1 Standard of Length, Mass and Time

- Physical quantities
  - **Base quantities**
  - **Derived quantities**

Quantity	Unit
Length	meter
Time	second
Mass	kilogram
Electric Current	ampere
Temperature	kelvin
Amount of Substance	mole
Luminous Intensity	candela

Other quantities defined in terms 7 base quantities e.g.: Area (product of two length)

1.2 Dimensional Analysis

- Dimension has a specific meaning – it represent the physical nature of a quantity (base quantity that make it up)

- Dimensions are denoted with square brackets e.g.
  - Length [*L*]
  - Mass [*M*]
  - Time [*T*]

1.2 Dimensional Analysis

- Each dimension could have many units.

- For e.g.: dimension of area always $[L^2]$: the unit can be m^2, ft^2, cm^2 and so on.

- The formula for a derived quantity may be different, but dimension must be the same.

- E.g. : The area of a triangle is $A = ½ bh$, whereas area of circle is πr^2.
  - Both triangle and circle area dimensions are always $[L^2]$.

1.2 Dimensional Analysis

Dimensional analysis can be used to:

a. To check the homogeneity / consistency of an equation & to prove the validity of an equation.
b. To determine the SI unit of any physical quantity.

1.2 Dimensional Analysis

Problem Solving Strategy:

1. Dimensions can be treated as algebraic quantities can be added, subtract or multiply, divide.
2. Both sides of equation must or need to have the same dimensions
3. There are no dimensions for constant
4. Any relationship can be correct only if the dimensions on both sides of the equation are the same

1.2 Dimensional Analysis

Example 1

Given $x = \frac{1}{2}at^2$. Is this equation correct?

Answer:

$$[L] = \frac{[L]}{[\not{T}^2]}[\not{T}^2] = [L]$$

T[2] is cancel

$$\text{LHS} = \text{RHS}$$

$$\therefore \text{ Dimensionally correct}$$

1.2 Dimensional Analysis

<u>Example 2</u>

Determine weather this equation true or not.

$$v = v_o + \frac{1}{2}at^2$$

Answer:

$$\frac{[L]}{[T]} = \frac{[L]}{[T]} + \frac{[L]}{[\cancel{T}^2]}[\cancel{T}^2]$$

$$\text{LHS} \neq \text{RHS} \qquad \therefore \text{ Incorrect equation}$$

1.2 Dimensional Analysis

Example 3 Determine the SI unit of density. Given density is mass per unit volume.

Answer:

$$\rho = \frac{m}{v} = \frac{[M]}{[L^3]}$$

$[M]$ → Unit: kg

$[L^3]$ → Unit: m^3

$$\therefore \text{ SI unit of density : kg/m}^3$$

1.3 Conversion of unit

- Often, we are given a quantity in one sets of units, but we want to expressed in another set of unit.
  - e.g.: suppose a table is 21.5 In wide, in cm?

$$21.5 \text{ inches} = (21.5 \not{\text{in.}}) \times \left(2.54 \frac{\text{cm}}{\not{\text{in.}}}\right) = 54.6 \text{ cm}.$$

Conversion factor

Unit conversions always involve
a conversion factor.
Example: 1 in. = 2.54 cm.
Written another way: 1 = 2.54 cm/in.

1.3 Conversion of unit

- Conversion Factor

Length		
1 in.	= 2.54 cm (defined)	
1 cm	= 0.3937 in.	
1 ft	= 30.48 cm	
1 ft	= 12 in.	
1 m	= 39.37 in.	= 3.281ft
1 mi	= 5280 ft	= 1.609 km
1 km	= 0.6214 mi	

1.3 Conversion of unit

Example 4

Convert 15.0 In. to cm.

Answer:

From

$$1 \text{ In.} = 2.54 \text{ cm}$$

Conversion Factor

$$1 = \frac{2.54 \text{ cm}}{1 \text{ In.}}$$

$$\therefore\ 15 \text{ In.} = (15 \not{\text{In.}}) \times \left(\frac{2.54 \text{ cm}}{1 \not{\text{In.}}} \right) = 38.1 \text{ cm}$$

1.3 Conversion of unit

<u>Example 5</u>

Eight-thousanders are located in the Himalayan and Karakoram mountain ranges in Asia and their peaks are over 8000 m above sea level. What is the elevation, in feet, of an 8000 m?

1.3 Conversion of unit

Example 5: Answer

$$8000\text{ m} = (8000\text{ m}) \times \left(\frac{3.281\text{ ft.}}{1\text{ m}}\right) = 26248\text{ ft.}$$

or

$$8000\text{ m} = (8000\text{ m}) \times \left(\frac{39.37\text{ in.}}{1\text{ m}}\right) \times \left(\frac{1\text{ ft.}}{12\text{ in.}}\right) = 26247\text{ ft.}$$

or

$$8000\text{ m} = (8000\text{ m}) \times \left(\frac{100\text{ cm}}{1\text{ m}}\right) \times \left(\frac{0.3937\text{ in.}}{1\text{ cm}}\right) \times \left(\frac{1\text{ ft.}}{12\text{ in.}}\right) = 26247\text{ ft.}$$

1.3 Conversion of unit

Example 6

An apartment have floor area is 880 square feet (ft^2). What is its area in square meter?

We use the same factor, but twice!

Answer:

$$880\ \text{ft}^2 = \left(880\ \cancel{\text{ft}}^2\right) \times \left(\frac{(1\ \text{m})^2}{(3.281\ \cancel{\text{ft}})^2}\right) = 82\ \text{m}^2 \qquad \text{or}$$

$$880\ \text{ft}^2 = \left(880\ \cancel{\text{ft}}^2\right) \times \left(\frac{(30.48\ \cancel{\text{cm}})^2}{(1\ \cancel{\text{ft}})^2}\right) \times \left(\frac{(1\ \text{m})^2}{(100\ \cancel{\text{cm}})^2}\right) = 82\ \text{m}^2$$

1.3 Conversion of unit

Example 7

The speed limit in Ipoh is 55 miles per hour (mi/h or mph), what is this speed

(a) in m/s

(b) in km/h

1.3 Conversion of unit

Example 7: Answer

Convert 1 unit by 1 unit

$$(a)\ 55\ \text{mi/h} = (55\ \text{mi/h}) \times \left(\frac{1.609\ \text{km}}{1\ \text{mi}}\right) \times \left(\frac{1000\ \text{m}}{1\ \text{km}}\right) \times \left(\frac{1\ \text{h}}{3600\ \text{s}}\right) = 24.6\ \text{m/s}$$

$$(b)\ 55\ \text{mi/h} = (55\ \text{mi/h}) \times \left(\frac{1.609\ \text{km}}{1\ \text{mi}}\right) = 88.5\ \text{km/h}$$